

# FINAL REPORT

**Principal Investigator:** Petra M. Stegmann  
**Project Title:** The Remote Sensing of Mineral Aerosols and Their Impact on Phytoplankton Productivity using SeaWiFS  
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The main objective of this proposal was to use SeaWiFS data to study the relationship between aerosols found in aeolian dust and photosynthesis of phytoplankton in open ocean surface waters. This project was a collaborative effort between myself and Dr. Neil Tindale at Texas A&M University and followed on our earlier funded proposal which had been designed as a proof-of-concept study to determine if ocean color sensors such as the Coastal Zone Color Scanner (CZCS) could be used to detect and map large-scale mineral aerosol plumes. Despite the large spatial and temporal gaps inherent in the CZCS data coverage, our results from this initial study indicated that an ocean color sensor could indeed be used to detect aerosols (Tindale and Yoder, 1990). These encouraging results led us to propose in this proposal the use of SeaWiFS data to study mineral aerosol transport and its impact on phytoplankton production.

This proposal originally intended to use SeaWiFS images, but as the launch delay of SeaWiFS dragged on, we had to make due with other satellite data sets. Thus, the focus of this proposal became the CZCS image archive instead. Below I detail my results and accomplishments with this data set.

In collaboration with Dr. Neil Tindale and his graduate student, Mr. Greg Giondomenica, I processed and mapped all available CZCS chlorophyll and aerosol radiance images for the coastal and ocean regions of Australia/New Zealand for the entire 1978–1986 time-period. This was carried out as part of Mr. Giondomenica's master thesis titled "Aerosol Analysis with the Coastal Zone Color Scanner: The Australasian Region". I performed all the initial processing of the raw images and he subsequently binned them and examined the seasonality of the aerosol load in that region. In his study he compared the CZCS-derived aerosol distribution patterns to climatological synoptic weather patterns. He found a clear relationship between the two with distinct signals to the northwest and southeast of Australia and in equatorial waters to the north and northeast.

I reanalyzed all CZCS aerosol radiance images from the perspective of studying the spatial and temporal variability of global aerosol patterns and how they relate to CZCS-chlorophyll maps on the same time and space scales. This was the first study to generate climatological global aerosol radiance maps using the 7.5-year CZCS data base. These global aerosol radiance maps coincided in seasonality and spatial coverage to those found

by other satellite sensors used to observe and track aerosols. I found CZCS- aerosol images successfully depicted increased aerosol radiances in well-documented regions known to have elevated levels of aerosols, such as off northwest Africa, the Arabian Sea, off the east coast of North America and in the northwest Pacific. Furthermore, 1) the subpolar and subtropical zones revealed higher aerosol radiances in the northern than the southern hemisphere, 2) the subtropics of both hemispheres indicated almost two times higher aerosol levels in summer than in winter, 3) aerosol levels in the subpolar regions were about three times higher in late spring/early summer than in winter, 4) increased levels of aerosols occurred in the Indian, Arctic, and Antarctic zones that preceded higher chlorophyll levels by about 1-2 months, and 5) the seasonality of aerosol radiance followed that of chlorophyll concentration in mid-latitude regions. Since one of the major drawbacks of the CZCS data set were the large gaps in temporal and spatial coverage, all data was binned as one-month images. As a result of such a low temporal resolution, a firm conclusion on whether there was a causal relationship between the observed increase in chlorophyll and the preceded increase in aerosol radiance could not be made with this data set.

In addition to the global perspective of aerosol patterns, I also was interested in regional or mesoscale variability. I extracted aerosol radiance from numerous subregions, primarily in the Atlantic Ocean, and generated monthly mean aerosol radiance loads in these subregions for the 7.5-year lifetime of the CZCS. Two of these that yielded a fairly complete time-series were regions located off the southeast U.S. coast and at Bermuda. This relatively "long" time-series showed repeatedly high aerosol loads at both sites during the summer and low levels during the winter. When compared with ground-based dust records and also with the aerosol optical signal derived from routine observations made with an independent satellite data set, my observations were in very good agreement with these. At these two subregions I also found interannual variability that corresponded to that measured at an island-based station located over one thousand miles away. To better understand what large-scale phenomenon may have caused this observed variability, I compared the annual mean aerosol radiance at both subregions for the entire time-period with the North Atlantic Oscillation (NAO) index, over the same time-period. The results showed a relatively good correspondence between the two. This in turn supported an earlier published conclusion that variability in dust patterns in the north Atlantic is linked to changes in the NAO.

As mentioned above, this proposal had planned on using SeaWiFS images to study aerosol patterns but this was not possible due to the extended launch delay. However, despite this handicap, my results clearly showed that the CZCS successfully captured large-scale aerosol plumes on a global scale as well as interannual variability of aerosol events on the mesoscale. The fact that my results showed a good correspondence with other independent data sets was quite unexpected. These results are even more remarkable given the fact that the main objective of the CZCS mission was not intended for aerosol observations. I have presented and published the above detailed results in the following manner:

**Presentations:**

Stegmann, P.M. and N.W. Tindale. 1998. Long term analysis of global aerosol distributions as derived from satellite observations. ASLO/Ocean Sciences Meeting; San Diego, CA.

Stegmann, P.M. and N.W. Tindale. 1998. The temporal and spatial variability of aerosols over the ocean as estimated from space-borne sensors. International Conference on Satellites, Oceanography, and Society; Lisbon, Portugal.

Stegmann, P.M. 2000. Remote Monitoring of Aerosols with Ocean Color Sensors: Then and Now. Oceans from Space; Venice, Italy.

**Publications:**

Stegmann, P.M. and N.W. Tindale. 1998. Long-term analysis of global aerosol distributions as derived from satellite observations. *EOS 79/Suppl.*: OS45.

Stegmann, P.M. and N.W. Tindale. 1999. Global distribution of aerosols over the open ocean as derived from the Coastal Zone Color Scanner. *Global Biogeochemical Cycles 13*: 383-397.

Stegmann, P.M. 2000. Ocean color satellites and the phytoplankton-dust connection. In: "Satellites, Oceanography and Society", D. Halpern (Ed.), Elsevier Science Ltd.: 207-223.